Justin's Office Hours: Monday 5:30 - 7 PM

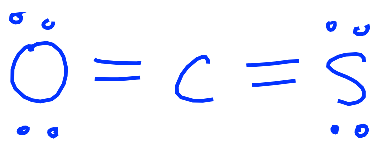
Location TBA

Chem E-1a
Friday Review Problems
Chapter 10: Chemical Bonding II

1. For each of the following molecules, draw a complete Lewis structure. Then determine the number of electron domains around the central atom and predict the hybridization, electron-pair geometry, and molecular geometry around the central atom. Finally, determine the approximate bond angles around the central atom and determine if the molecule is polar or nonpolar.

a) OCS

Lewis Structure



# of Electron Domains (Pairs): 2

Hybridization: SP

Electron-Pair Geometry: LINEAR

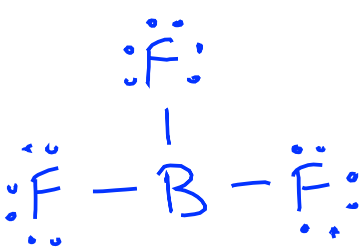
Molecular Geometry: LINEAR

Bond Angles: 180°

Polar or Nonpolar? POLAR

b) BF_3

Lewis Structure



# of Electron Domains (Pairs): 3

Hybridization: sp^2

Electron-Pair Geometry: TRIGONAL PLANAR

Molecular Geometry: TRIGONAL PLANAR

Bond Angles: 120°

Polar or Nonpolar?

1. (cont.)

c) IF_3

Lewis Structure

# of Electron Domains (Pairs): 5

Hybridization: sp^3d

Electron-Pair Geometry: TRIGONAL BIPYRAMIDAL

Molecular Geometry: T-SHAPED

Bond Angles: $< 90°$

Polar or Nonpolar?

d) SF_4

Lewis Structure

# of Electron Domains (Pairs):

Hybridization:

Electron-Pair Geometry:

Molecular Geometry:

Bond Angles:

Polar or Nonpolar?

SEE ANSWER KEY

e) XeF_4

Lewis Structure

# of Electron Domains (Pairs):

Hybridization:

Electron-Pair Geometry:

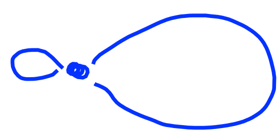
Molecular Geometry:

Bond Angles:

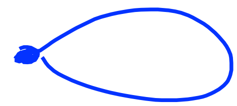
Polar or Nonpolar?

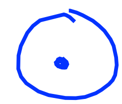
EVERY BOND CONTAINS A SIGMA-BOND
(σ-BOND)

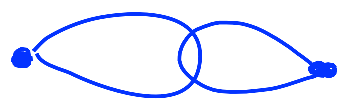
A <u>SIGMA BOND</u> IS A BOND BETWEEN HYBRID ORBITALS



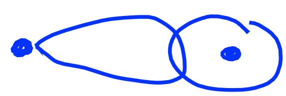
1 HYBRID ORBITAL

ABBREVIATE: 

(WITH HYDROGEN, FORM σ-BONDS USING 1s ORBITAL ON H: )



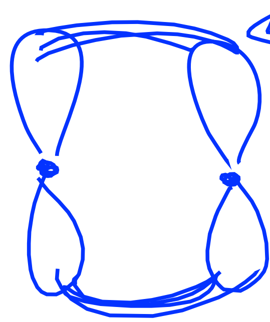
σ-BOND



σ-BOND TO A HYDROGEN

ANY TIME YOU HAVE A DOUBLE OR TRIPLE BOND YOU HAVE π-BONDING
(PI-BONDING)

A PI-BOND IS SIDE-BY-SIDE OVERLAP OF P ORBITALS (<u>ATOMIC</u>, UNHYBRIDIZED P-ORBITALS)

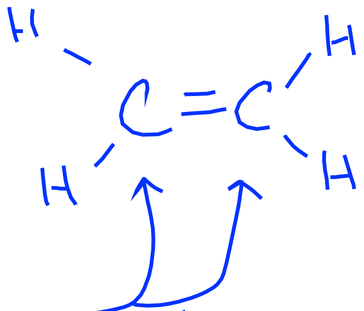


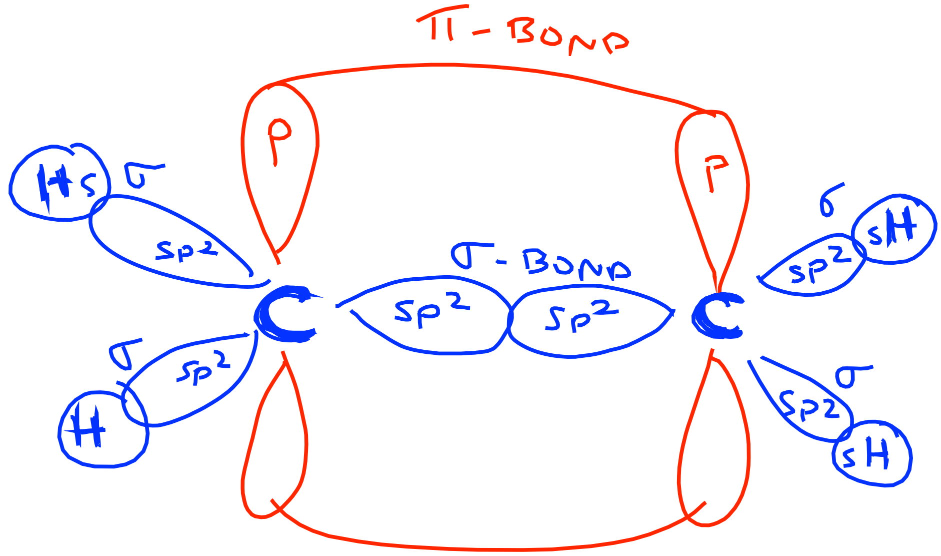
π-BOND

EVERY BOND CONTAINS A SIGMA-BOND
A

2. For each of the following, draw a sketch of the molecule that shows all of the sigma and pi bonds, and shows the orbitals that form each sigma and pi bond. Label all orbitals and bonds in your drawing.

a) H_2CCH_2



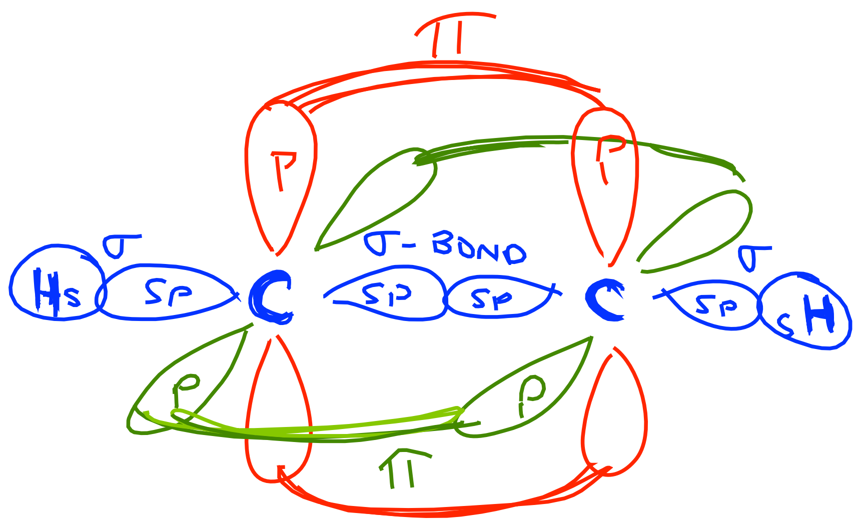


BOTH C's ARE SP2 ~~H~~ HYBRIDIZED

b) HCCH

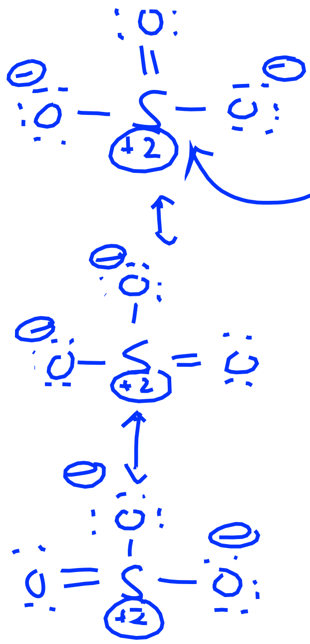
H − C ≡ C − H

SP HYBRIDIZED



3. For each of the following, draw a perspective sketch of the molecule using lines, dashes, and wedges that clearly shows the geometry of the molecule and the location and orientation of the pi bonding. Show any unhybridized p orbitals and connect them to indicate the pi bonding. Do not draw any orbitals involved in sigma bonding.

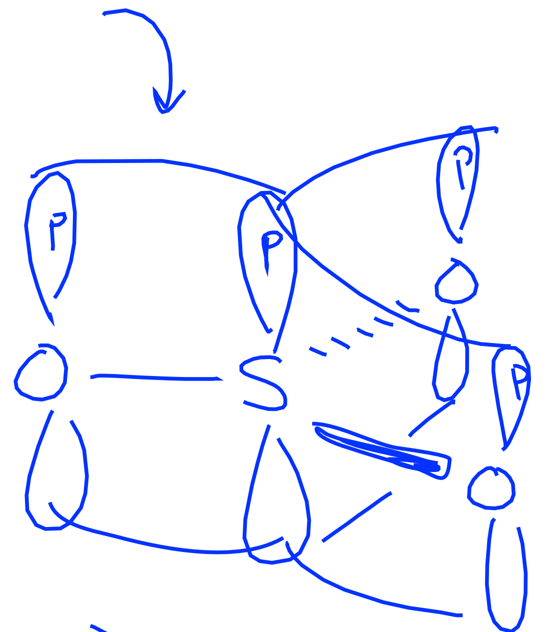
a) SO_3



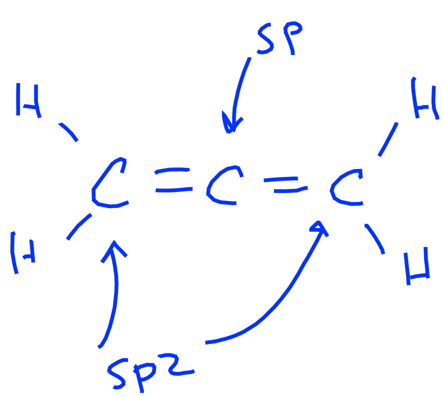
SULFUR IS sp^2 HYBRIDIZED

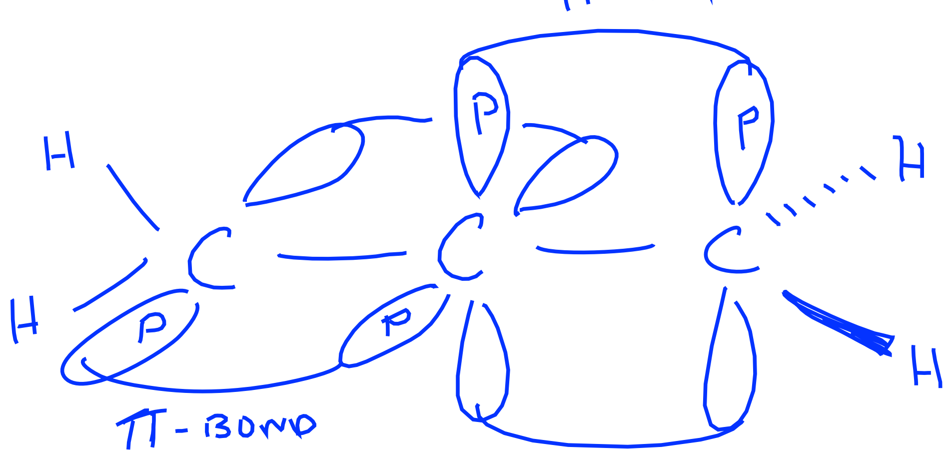
RESONANCE = DELOCALIZED π-BONDING

DELOCALIZED π-BOND



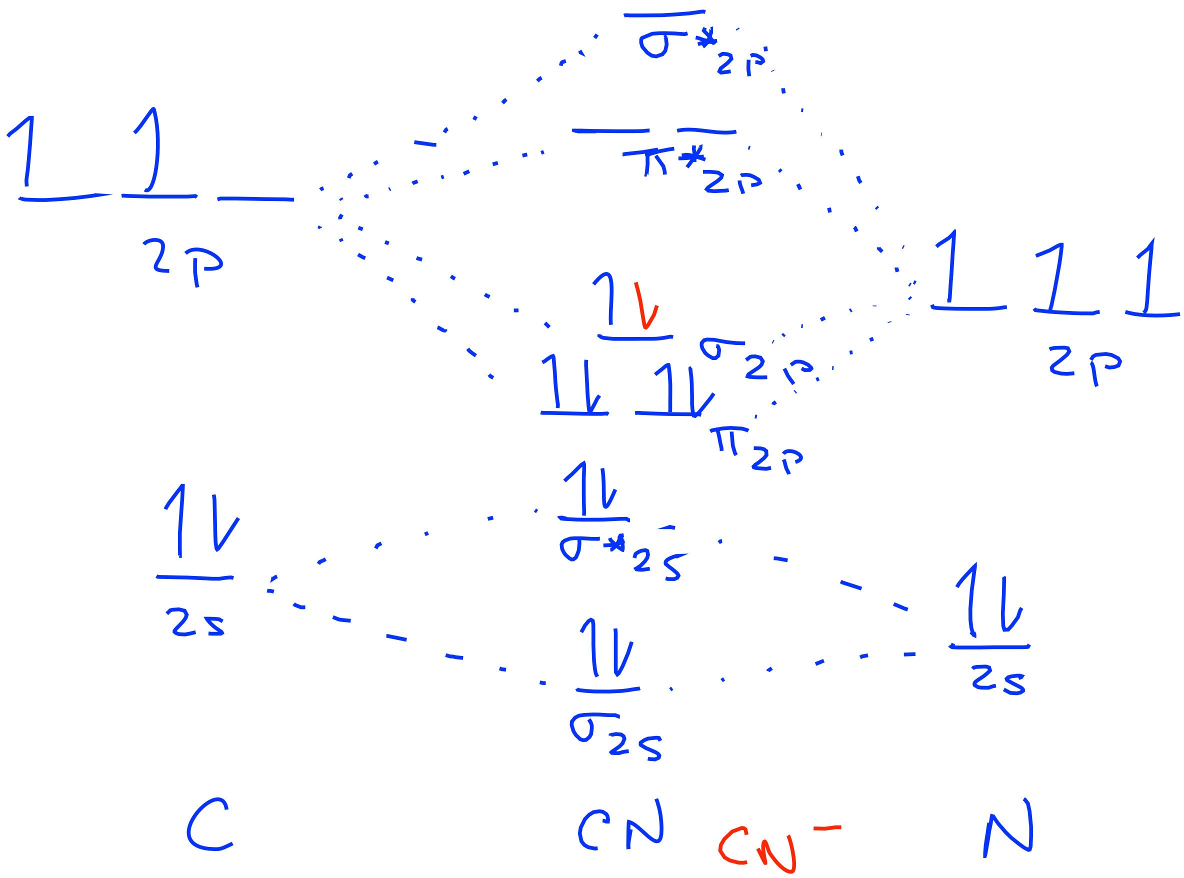
b) H_2CCCH_2





4. Consider the neutral CN molecule.

a) Draw a molecular orbital diagram for the valence molecular orbitals of CN. Include the relevant atomic orbitals in your diagram, and be sure to label your atomic and molecular orbitals. (Use the "BCN" ordering of energy levels.)



b) Is the CN molecule paramagnetic or diamagnetic?

HAS UNPAIRED e^-

c) What is the bond order of the neutral CN molecule?

$$B.O. = \frac{1}{2}(B.e^- - A.B.e^-)$$
$$= \frac{1}{2}(7 - 2) = 5/2 = 2.5$$

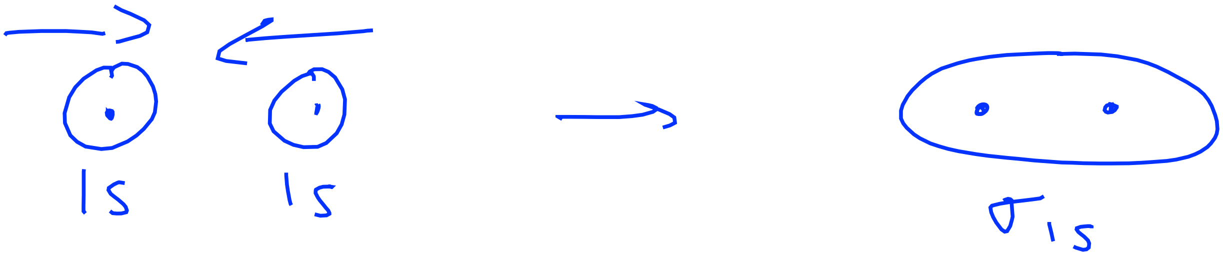
d) The CN molecule could gain an electron to form the cyanide ion, CN^-. Which of these two species, CN or CN^-, has the longer bond length?

CN^- $B.O. = \frac{1}{2}(8 - 2) = 3$

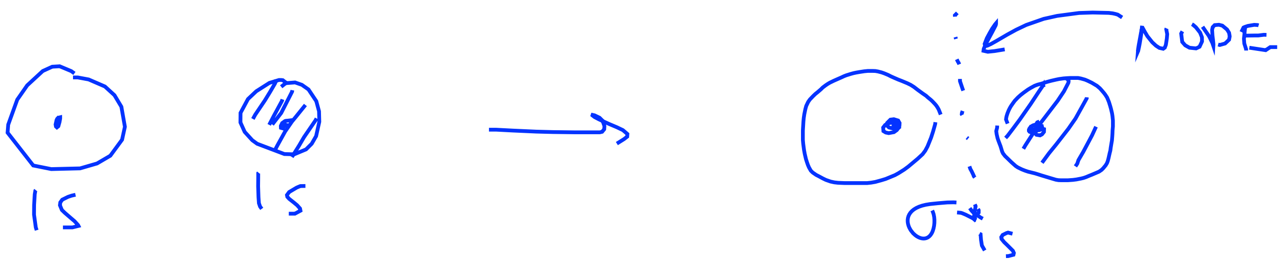
SMALLER BOND ORDER

5. For each of the following molecular orbitals, draw the atomic orbitals that would combine to form the indicated molecular orbital, showing the atomic orbitals with the correct orientation and shading for phase to form the molecular orbital indicated. Then draw a depiction of the molecular orbital. Be sure to shade your orbitals to indicate phase.

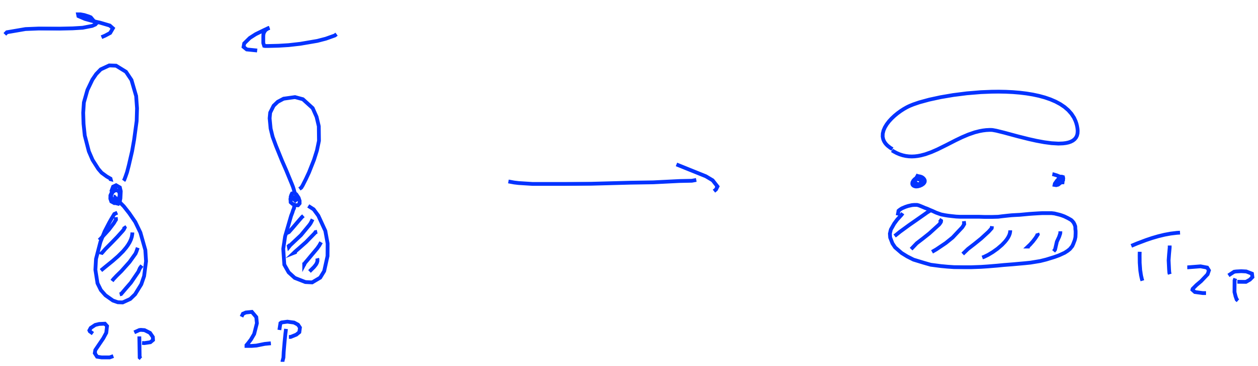
a) σ_{1s}



b) σ^*_{1s}



c) π_{2p}



d) π^*_{2p}